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Kusada et al.

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(54) **POWER CONVERTER DESIGNED TO MINIMIZE MECHANICAL VIBRATION OF CONVERTER COMPONENT**

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(51) **Int. Cl.**

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H05K 7/14 (2006.01)
H05K 5/00 (2006.01)
H05K 7/00 (2006.01)
H01L 23/473 (2006.01)

(52) **U.S. Cl.**

CPC ***H05K 7/1432*** (2013.01)

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USPC 361/679.01–679.45, 679.55–679.61, 361/724–727; 455/575.1–575.9; 349/56–60; 312/223.1–223.3; 257/712–722, E23.088

See application file for complete search history.

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(57) **ABSTRACT**

A power converter includes a converter casing made of an assembly of a first case body and a second case body. The first case body has a bottom plate. The second case body has a top plate. Side plates are arranged between the top plate and the bottom plate. A capacitor is disposed in the converter casing and includes a capacitor casing and a capacitor device which is sealed with potting resin so as to have a potting surface through which the potting resin is exposed outside the capacitor casing. The capacitor is fixed on the bottom plate with the potting surface oriented perpendicular to a normal direction of the bottom plate. A connector is provided which mechanically connects the bottom plate and the top plate and is located away from the side plates, thereby enhancing the suppression of mechanical vibration of the capacitor on the bottom plate.

11 Claims, 12 Drawing Sheets

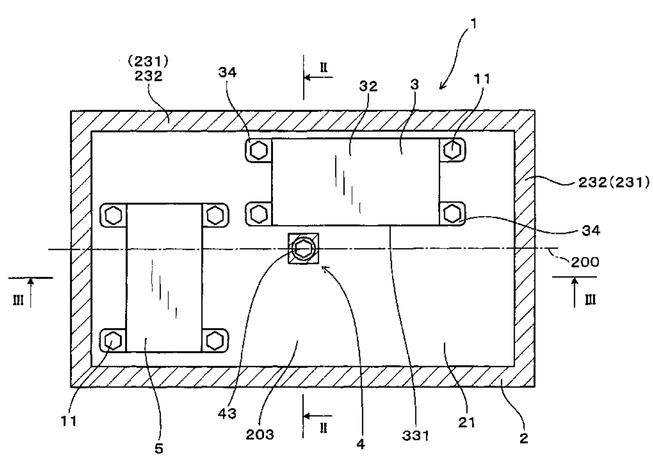

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FIG. 1

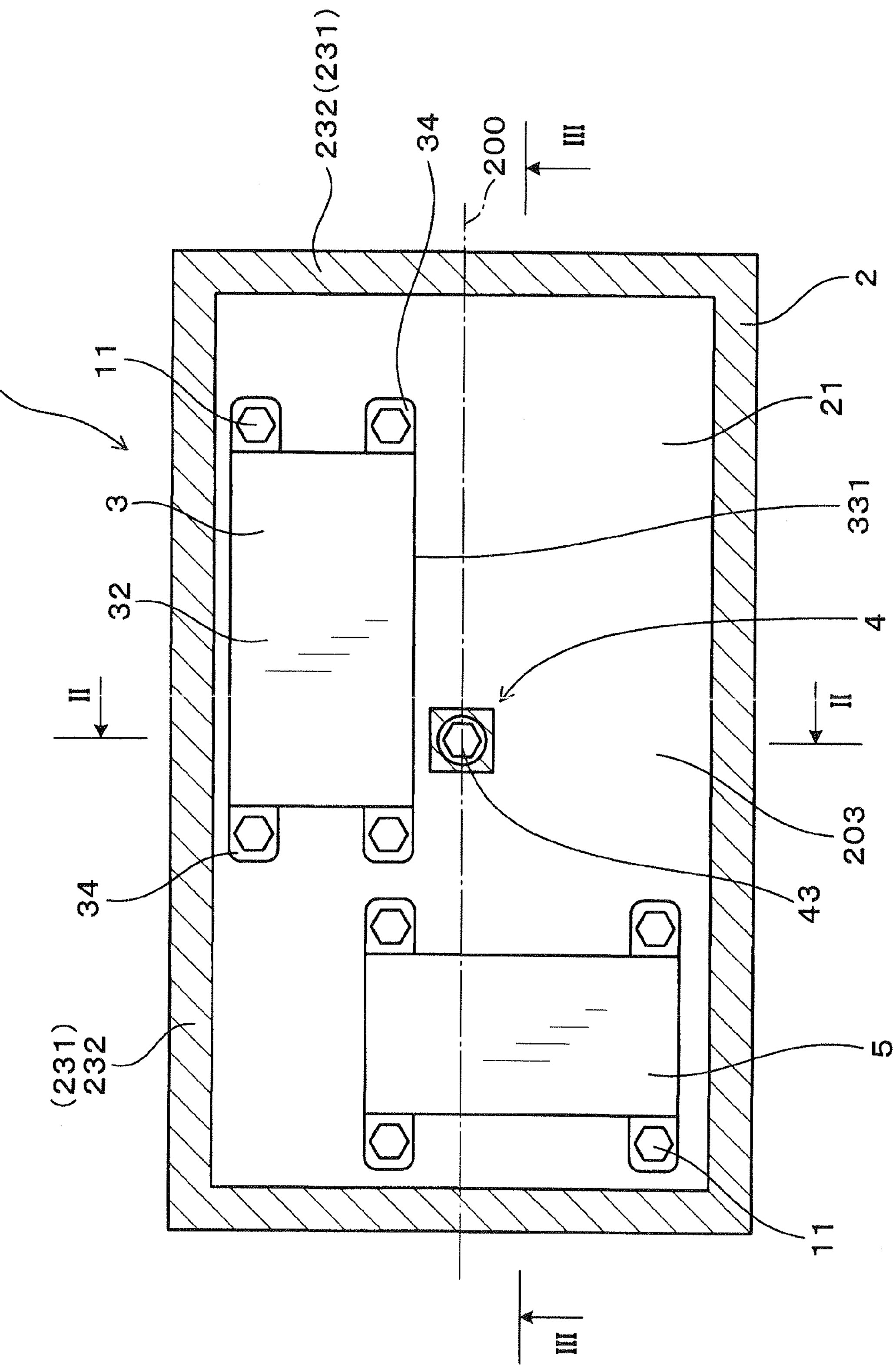

1
11
3
32
34
232(231)
34
200
III
II
2
21
331
4
203
43
5
11
(231)
232
III
II

FIG.2

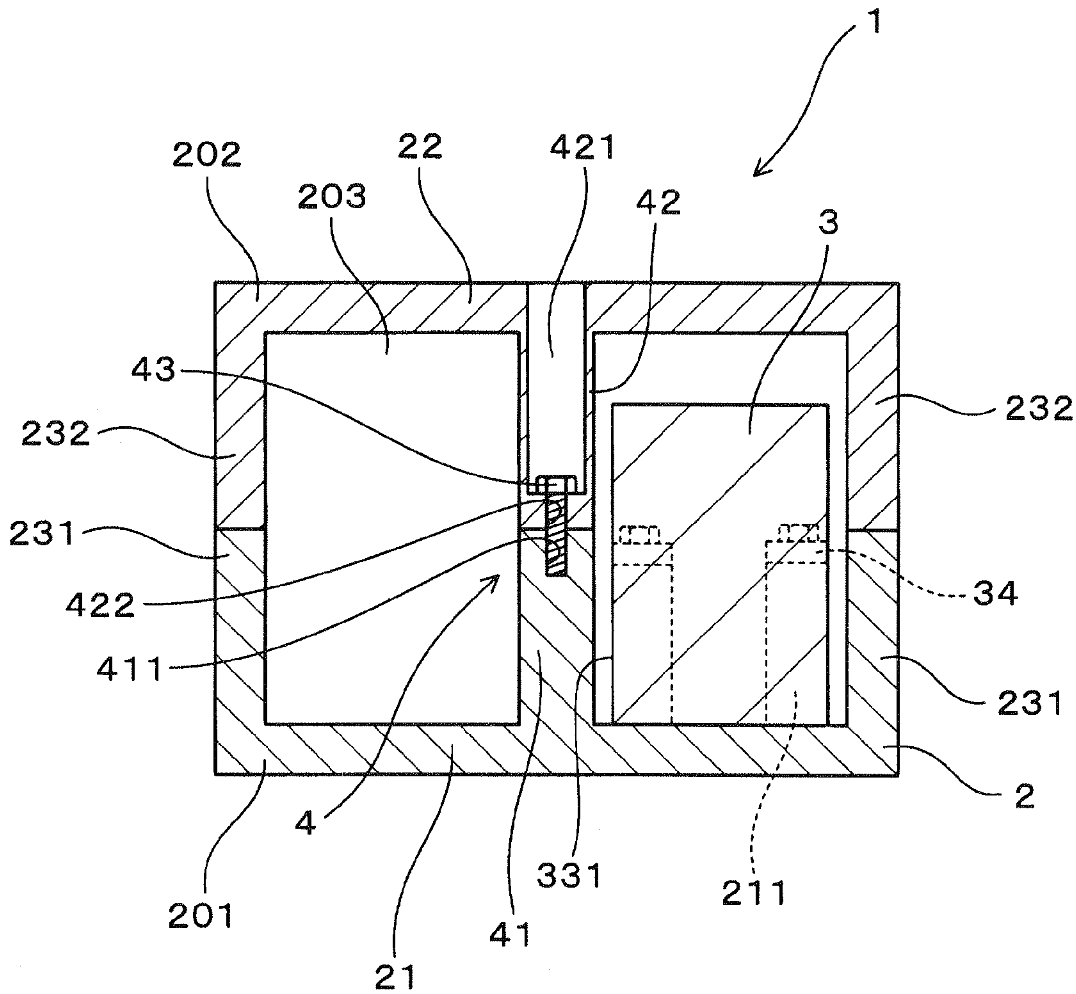

1
202
22
421
203
42
3
43
232
232
231
34
422
411
231
4
2
331
211
201
41
21

FIG.3

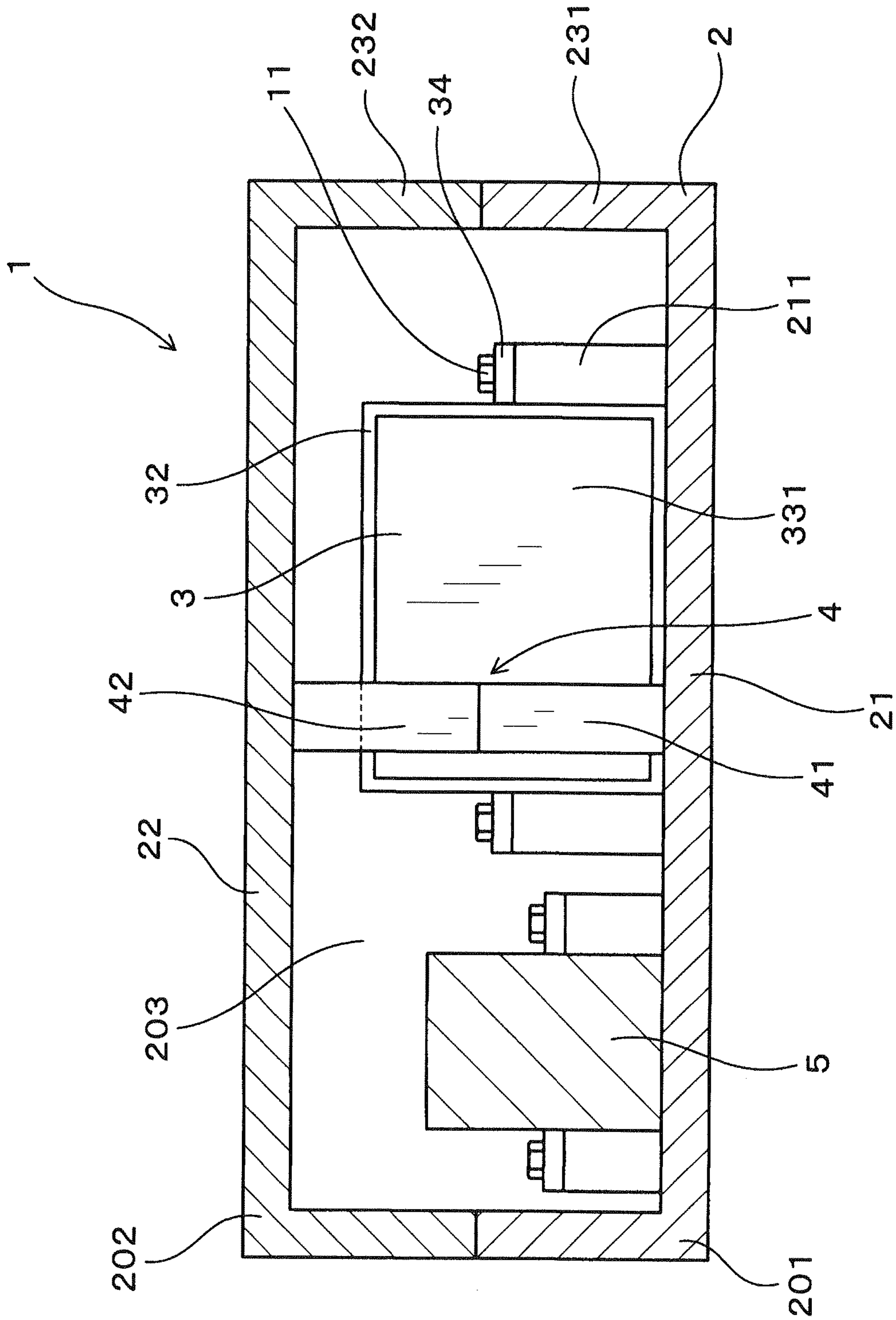


FIG.4

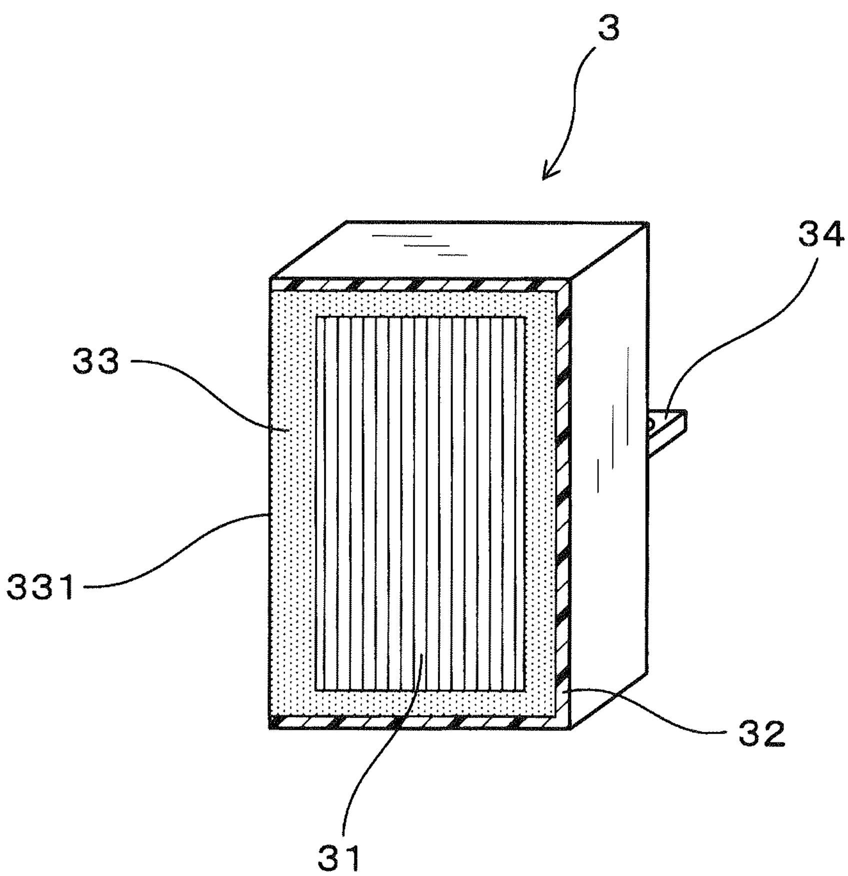


FIG. 5

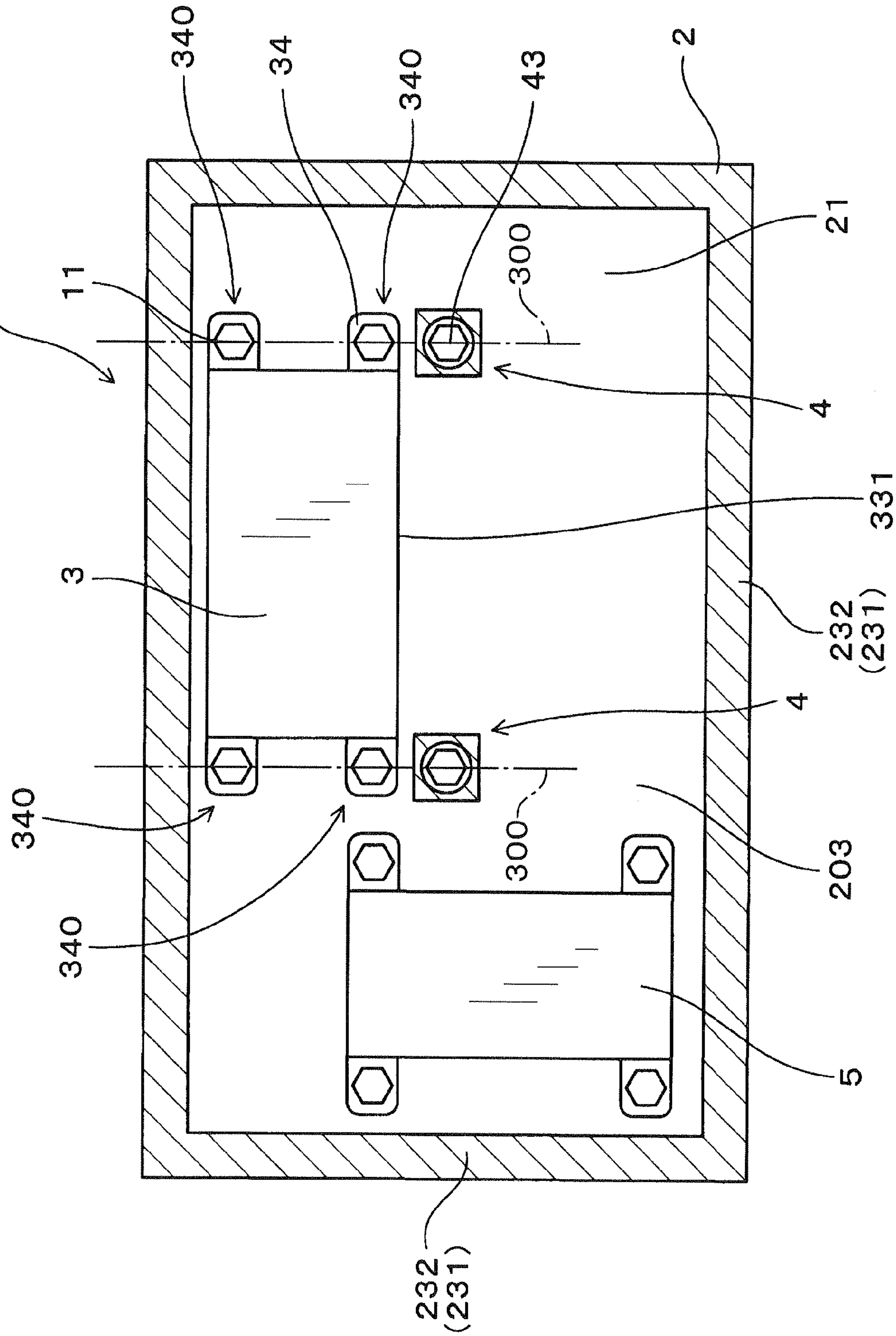
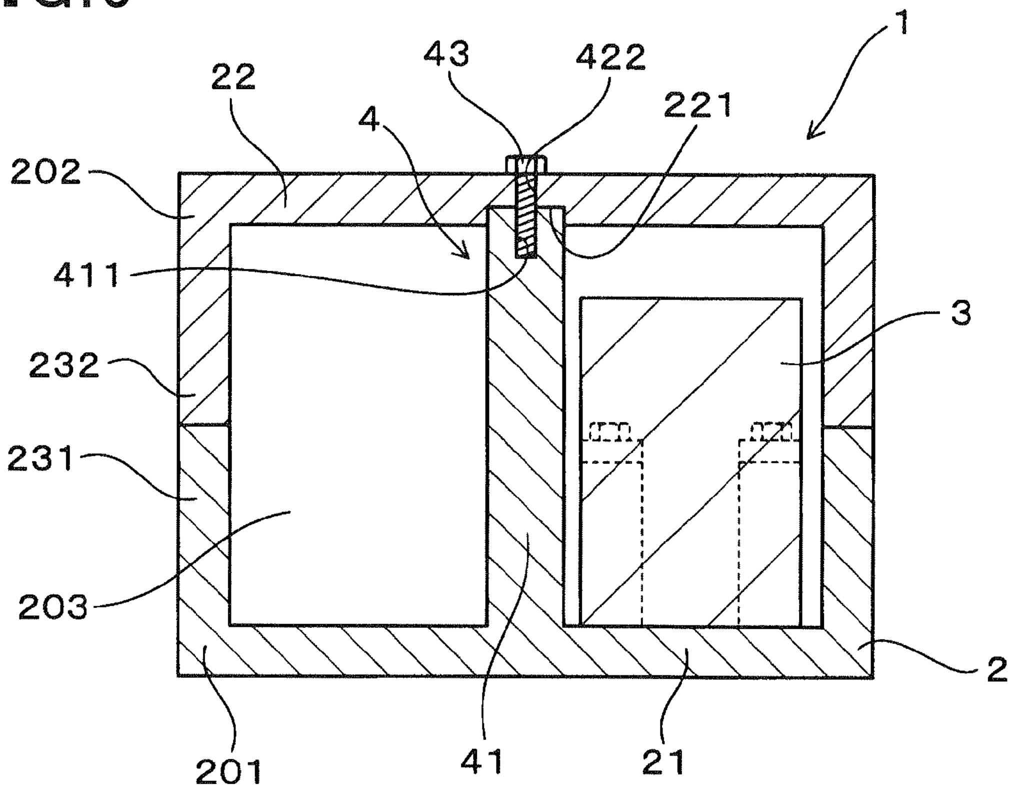

340
34
340
43
2
21
300
11
1
4
331
3
232
(231)
4
340
300
203
340
5
232
(231)

FIG.6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43
422
22
221
4
202
411
3
232
231
203
2
201
41
21

FIG.7

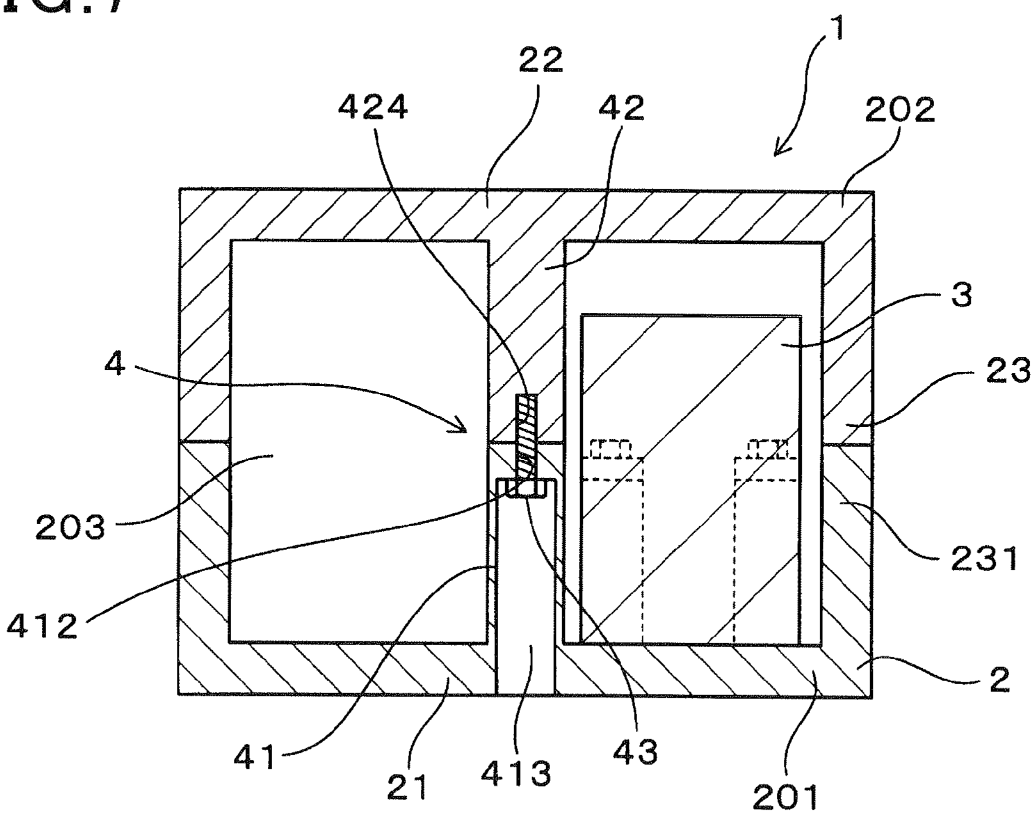
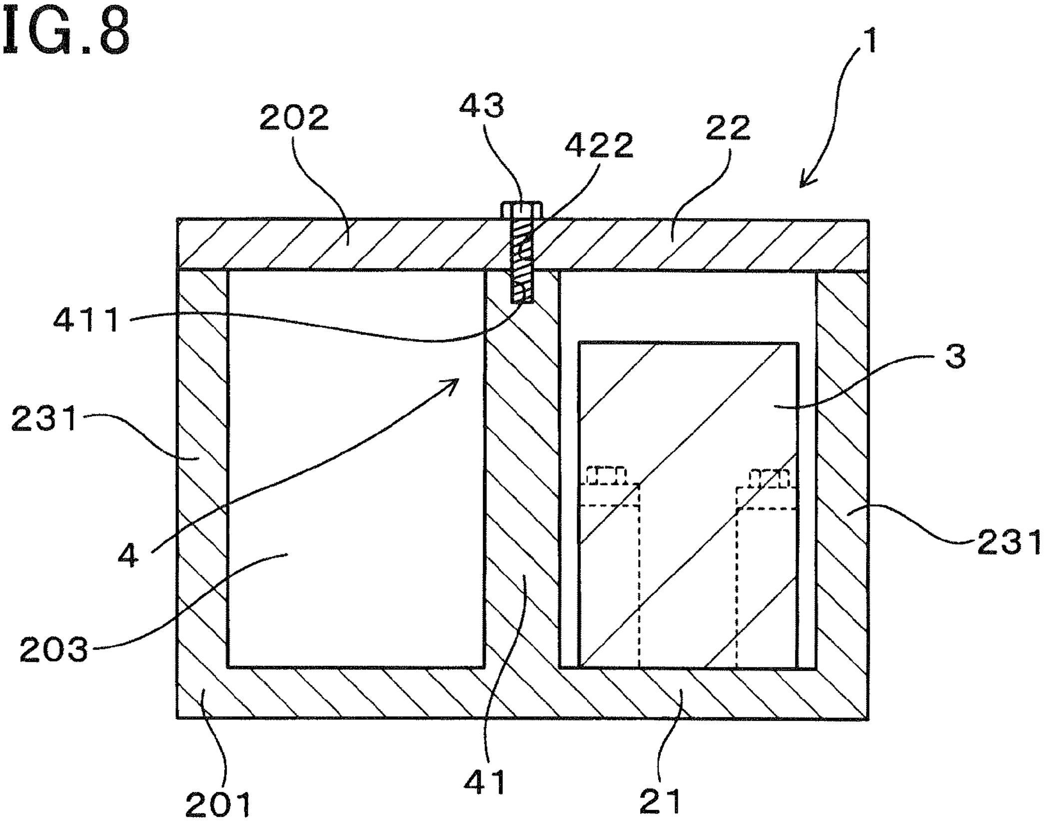

1
22
424
42
202
3
232
4
203
231
412
2
41
21
413
43
201

FIG.8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202
43
422
22
411
3
231
4
231
203
201
41
21

FIG.9

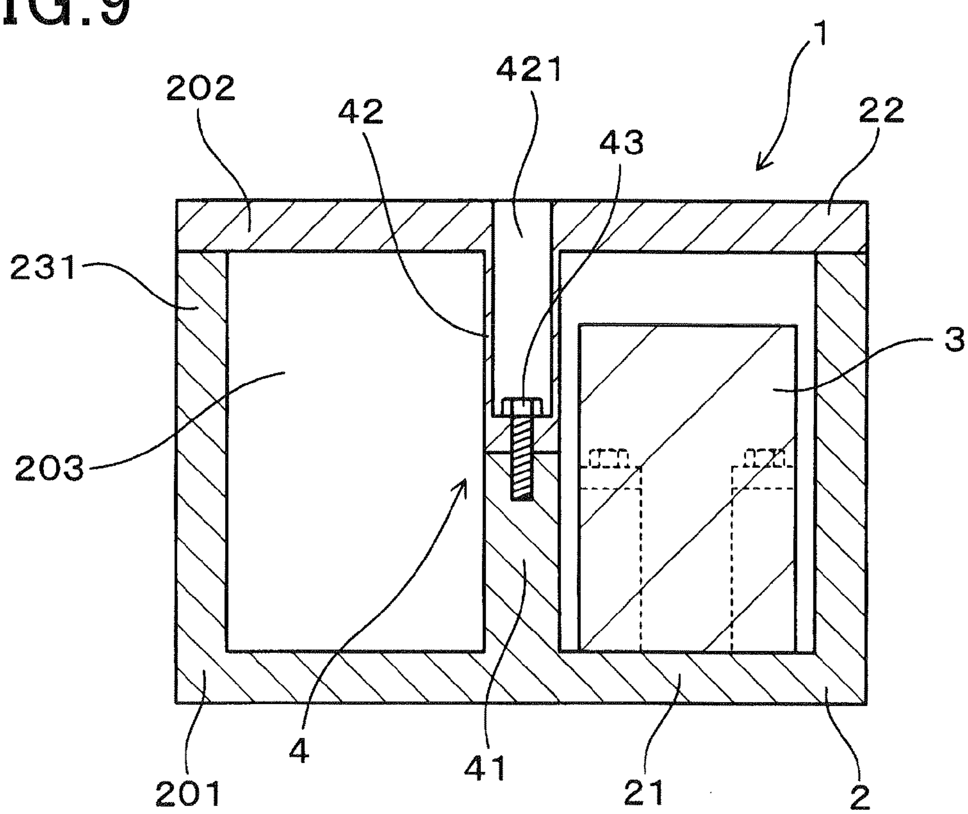
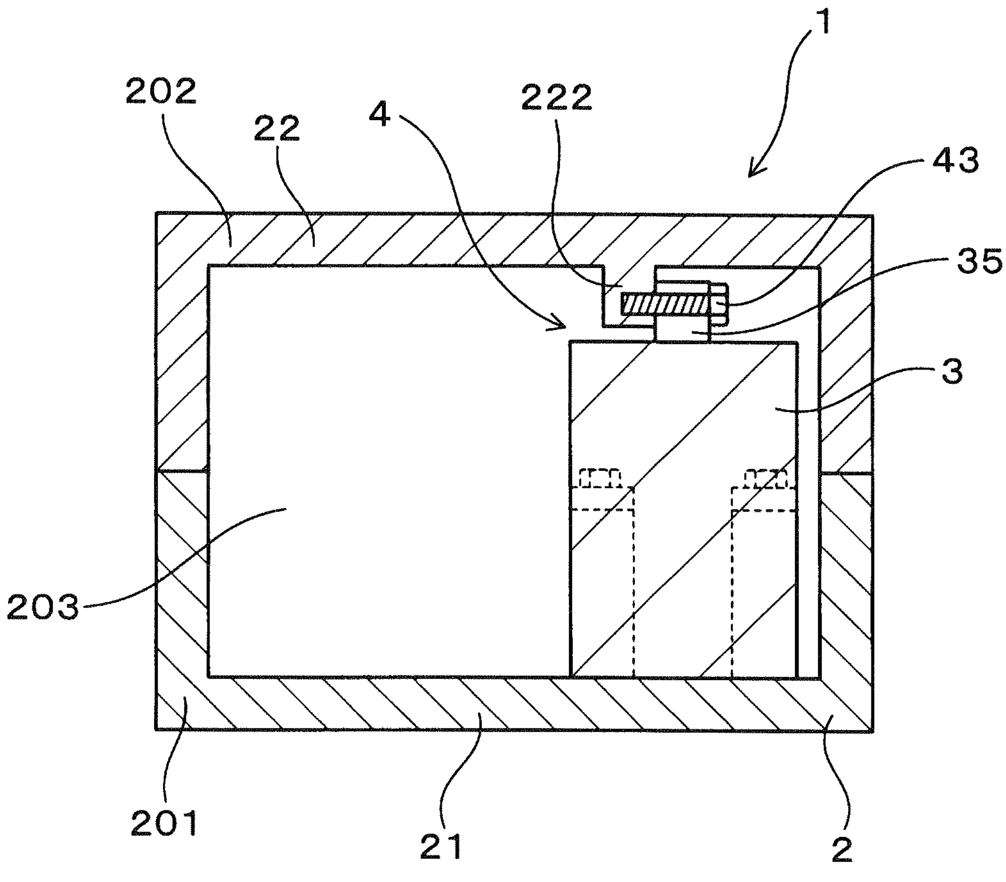

1
421
202
42
43
22
231
3
203
4
41
201
21
2

FIG.10



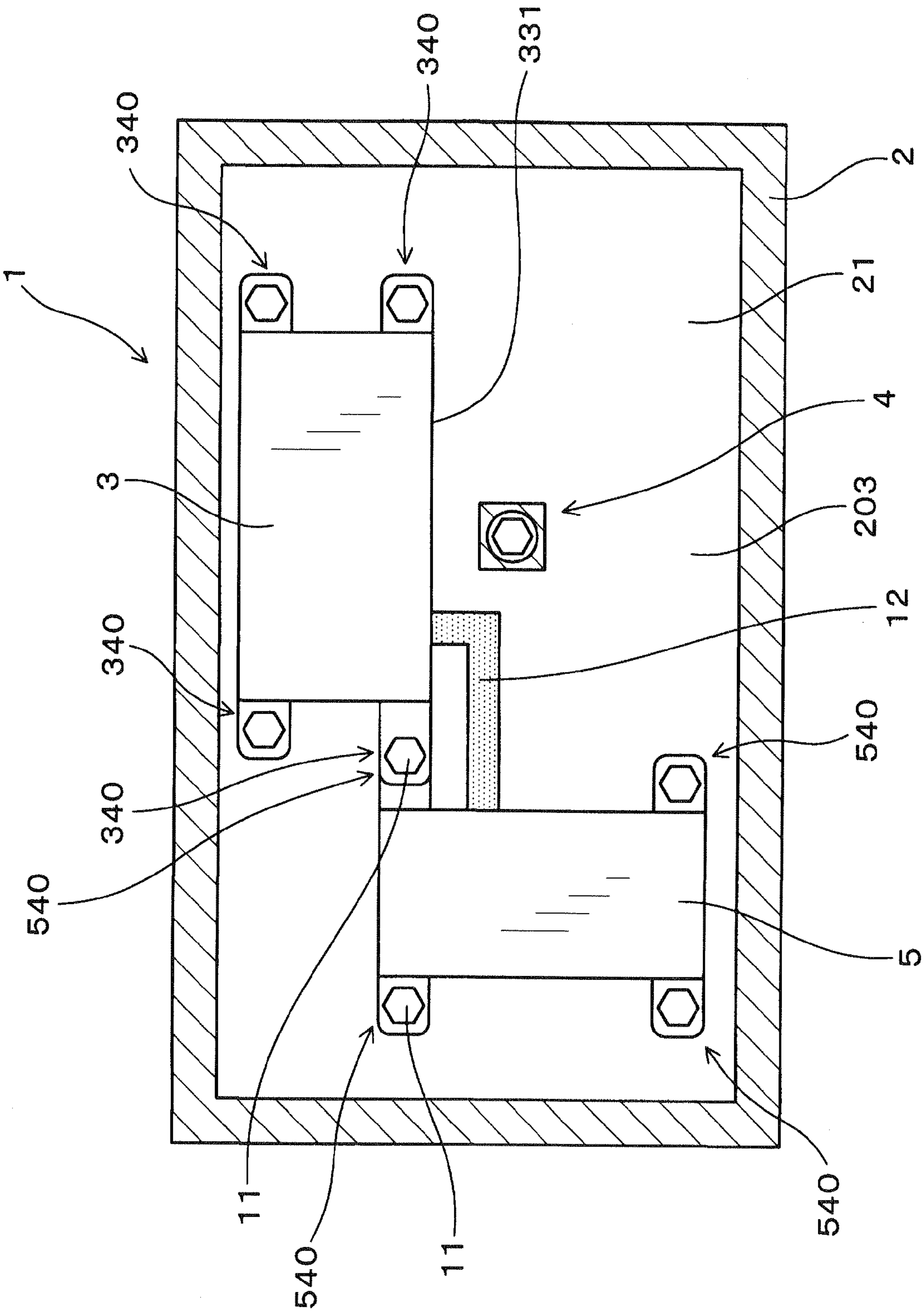


FIG. 11

FIG.12

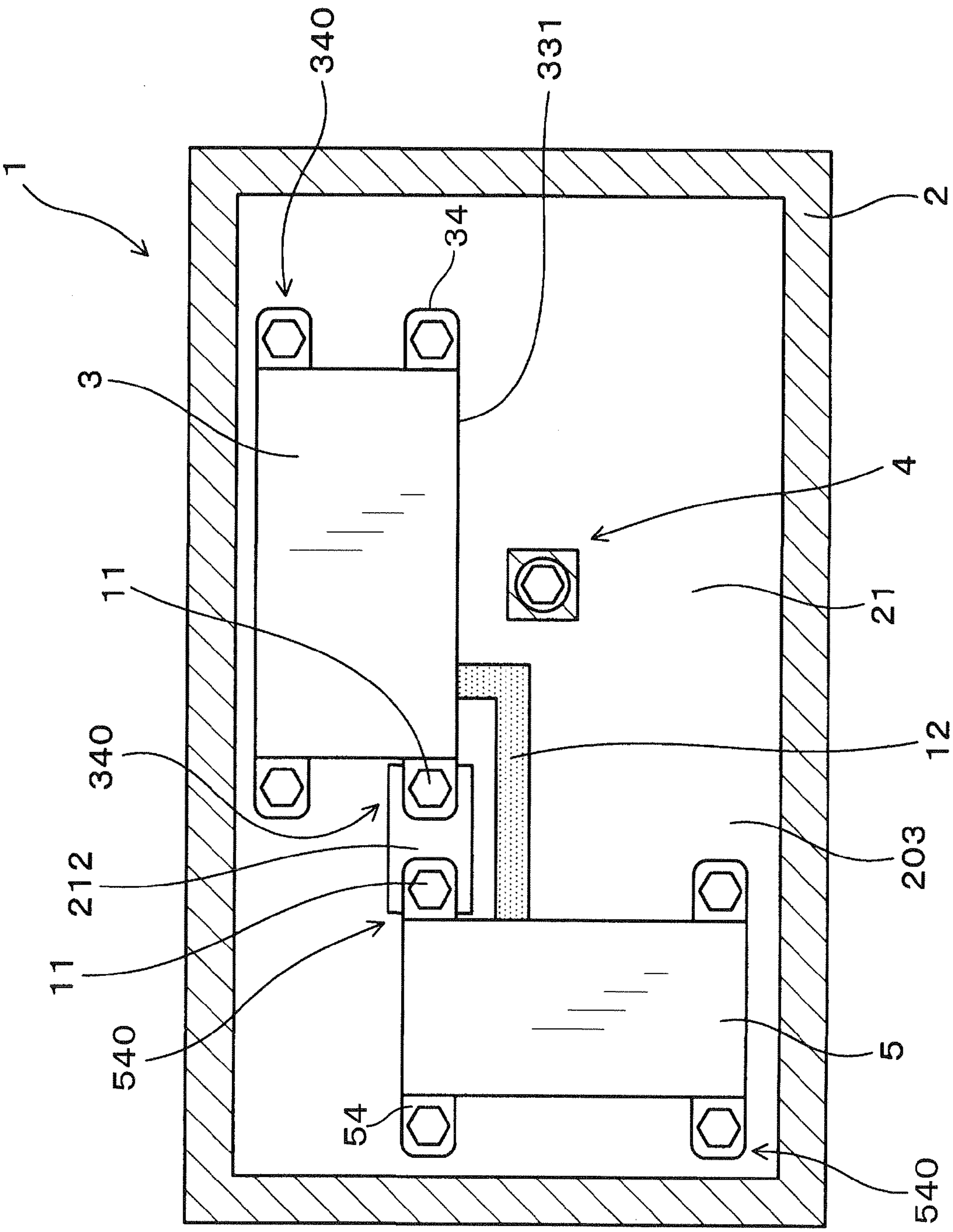


FIG.13

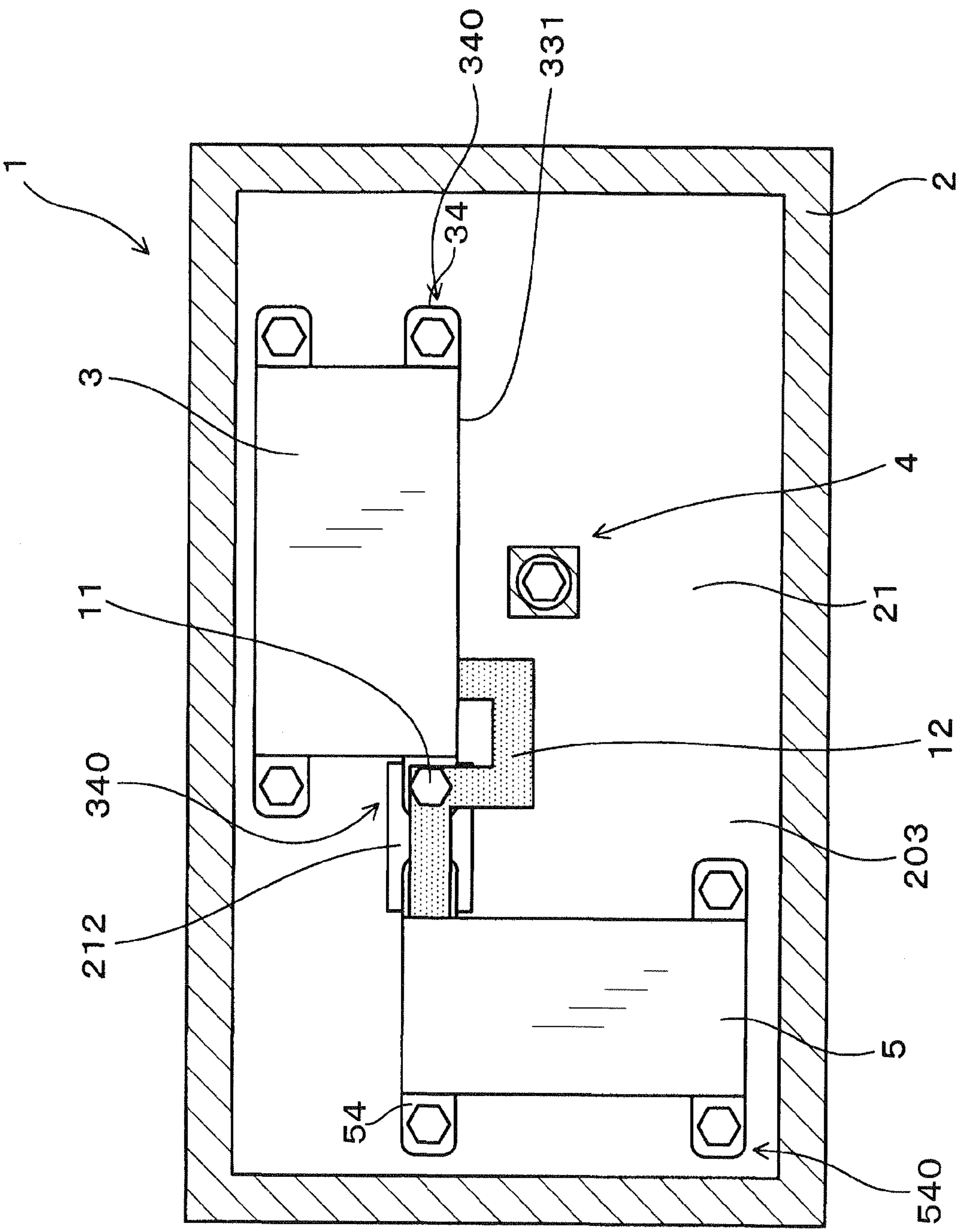
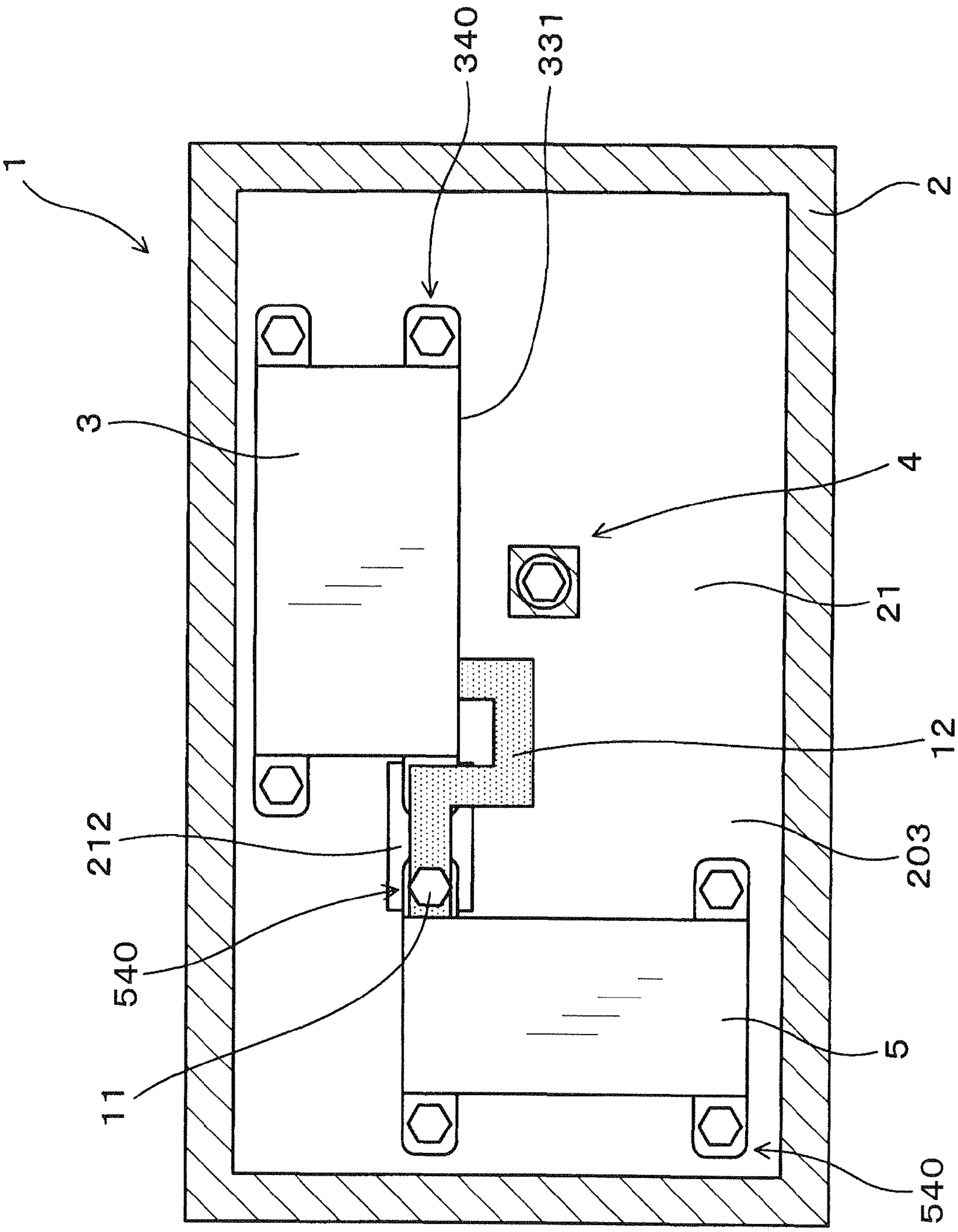


FIG.14



POWER CONVERTER DESIGNED TO MINIMIZE MECHANICAL VIBRATION OF CONVERTER COMPONENT

CROSS REFERENCE TO RELATED DOCUMENT

The present application claims the benefit of priority of Japanese Patent Application No. 2013-78530 filed on Apr. 4, 2013, the disclosure of which is incorporated herein by reference.

BACKGROUND

1. Technical Field

This application relates generally to a power converter whose casing is made of an assembly of a first case and a second case and which has a capacitor mounted in a storage chamber defined inside the casing.

2. Background Art

Japanese Patent First Publication No. 2009-201257 discloses a power converter, such as an inverter mounted in electric vehicles or hybrid vehicles, which has a capacitor mounted within a converter casing. The capacitor is made of a capacitor casing and a capacitor device disposed in the capacitor casing and sealed with potting resin. The potting resin is partially exposed outside the capacitor casing to have a potting surface. The capacitor is mounted on a base with the potting surface facing the surface of the base.

Usually, the potting surface defines a major surface which is the greatest in area of the capacitor. Thus, the arrangement of the capacitor with the potting surface directly placed on the base will cause the capacitor to occupy a great area of a parts-mounting surface of the base, which requires a need for widening the parts-mounting surface of the base in order to secure an area for other parts. This leads to a difficulty in decreasing the size of the power converter in a planar direction of the capacitor.

In view of the above problem, it may be proposed to arrange the capacitor on the base with the potting surface oriented perpendicular to a normal direction of the base (i.e., a bottom of the converter casing) in order to make efficient use of a storage space in the casing and facilitate a decrease in size of the power converter. Such an orientation of the potting surface is also desirable in terms of simplicity of layout of terminals of the capacitor in the case where the terminals of the capacitor protrude from the potting surface and are joined to a switching circuit or a reactor arranged away from each other in the planar direction of the bottom of the casing.

The arrangement of the capacitor with the potting surface oriented perpendicular to the planar direction of the bottom of the converter casing, however, may result in a problem that facilitates the physical vibration of the capacitor. Specifically, the mounting of the capacitor on the converter casing is achieved by securing the capacitor casing to the bottom of the converter casing. It is usually impossible to secure an area for the securement of the capacitor casing on the potting surface. The capacitor casing is, therefore, fixed on an area of the bottom of the capacitor casing other than the potting surface. It is difficult for such an arrangement of the capacitor casing to avoid the physical vibrations of the capacitor in a direction in which the capacitor leans toward the potting surface when the power converter is subjected to mechanical vibrations. For instance, when the vehicle vibrates, it may increase the vibrations of the capacitor toward the potting surface, which results in an increase in physical load on terminals of the capacitor which connect with other parts.

SUMMARY

It is therefore an object of this disclosure to provide an improved structure of a power converter which is designed to minimize the mechanical vibration of a capacitor installed in the power converter.

According to one aspect of an embodiment, there is provided a power converter which may be employed in automotive vehicles such as electric cars or hybrid cars. The power converter comprises: (a) a converter casing which is made of an assembly of a first case body and a second case body and has a storage chamber defined therein, the first case body including a bottom plate, the second case body including a top plate which faces the bottom plate, at least one of the first case body and the second case body having side plates which extend from a corresponding one of the bottom plate and the top plate to the other; (b) a capacitor which is secured to the bottom plate within the storage chamber of the converter casing, the capacitor including a capacitor casing and a capacitor device which is disposed within the capacitor casing and sealed with potting resin so as to have a potting surface through which the potting resin is exposed outside the capacitor casing, the capacitor being fixed on the bottom plate with the potting surface oriented perpendicular to a normal direction of the bottom plate; and (c) a connector which mechanically connects the bottom plate of the first case body and the top plate of the second case body and is located away from the side plates.

Specifically, the connector works to establish a mechanical joint of the bottom plate and the top plate of the converter casing at a location away from the side plates, thereby enhancing the suppression of mechanical vibration of the bottom plate.

The inventors of this application have found that a major cause of mechanical vibration of the capacitor resides on mechanical vibration of the bottom plate of the first case body which arises from deformation thereof. Specifically, the exertion of vibration, as transmitted to the power converter, on the capacitor causes stress to be transferred from the joint of the capacitor to the bottom plate. Such stress will result in the deformation of the bottom plate, which leads to the vibration of the capacitor fixed on the bottom plate in the converter casing.

In order to alleviate the above problem, the power converter is designed to have the connector which mechanically joints the bottom plate of the first case body and the top plate of the second case body together and is located apart from the side plates of the converter casing. In other words, the connector is provided on a portion of the bottom plate which is relatively lower in stiffness and is separate from the side plates. Such a location is effective in decreasing the deformation of the bottom plate, thus resulting in a decrease in vibration of the capacitor mounted on the bottom plate. This also decreases the degree of stress acting on terminals of the capacitor which are connected to another component of the power converter.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given hereinbelow and from the accompanying drawings of the preferred embodiments of the invention, which, however, should not be taken to limit the invention to the specific embodiments but are for the purpose of explanation and understanding only.

In the drawings:

FIG. **1** is a partially sectional plane view which illustrates a power converter according to the first embodiment;

FIG. **2** is a sectional view taken along the line II-II in FIG. **1**;

FIG. **3** is a sectional view taken along the line III-III in FIG. **1**;

FIG. **4** is a perspective sectional view of a capacitor mounted in the power converter of FIG. **1**;

FIG. **5** is a partially sectional plane view which illustrates a power converter according to the second embodiment;

FIG. **6** is a vertical sectional view which shows a power converter according to the third embodiment;

FIG. **7** is a vertical sectional view which shows a power converter according to the fourth embodiment;

FIG. **8** is a vertical sectional view which shows a power converter according to the fifth embodiment;

FIG. **9** is a vertical sectional view which shows a power converter according to the sixth embodiment;

FIG. **10** is a vertical sectional view which shows a power converter according to the seventh embodiment;

FIG. **11** is a partially sectional plane view which illustrates a power converter according to the eighth embodiment;

FIG. **12** is a partially sectional plane view which illustrates a power converter according to the ninth embodiment;

FIG. **13** is a partially sectional plane view which illustrates a power converter according to the tenth embodiment; and

FIG. **14** is a partially sectional plane view which illustrates a modification of the power converter of the tenth embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, wherein like reference numbers refer to like parts in several views, particularly to FIGS. **1** to **4**, there is shown a power converter **1** according to the first embodiment which may be mounted in automotive vehicles such as electric vehicles or hybrid vehicles. The power converter **1** is, as illustrated in FIGS. **1** to **3**, equipped with a converter casing **2** and a capacitor **3**. The converter casing **2** is made of an assembly of a first case body **201** and a second case body **202** and has a storage chamber **203** defined therein. The capacitor **3** is disposed in the storage chamber **203**.

The first case body **201**, as illustrated in FIGS. **2** and **3**, has a bottom plate **21** to which the capacitor **3** is secured. The second case body **202** is equipped with a top board or plate **22** facing the bottom plate **21**. The first case body **201** has side plates **231** which extend from the bottom plate **21** toward the top plate **22** of the second case body **202**. Similarly, the second case body **202** has side plates **232** which extend from the top plate **22** toward the bottom plate **21** of the first case body **201**.

FIG. **4** is a longitudinal perspective sectional view which illustrates the capacitor **3**. The capacitor **3** is, as clearly illustrated in FIG. **4**, made of an assembly of a capacitor device **31**, a potting resin **33**, and a capacitor casing **32**. Specifically, the capacitor device **31** is disposed within the capacitor casing **32** and sealed with the potting resin **33**. The capacitor **3** has a potting surface **331** that is one of outer surfaces thereof and through which the potting resin **33** is exposed outside the capacitor casing **32**. The capacitor **3** is, as can be seen from FIGS. **1** to **3**, fixed on the bottom plate **21** with the potting surface **331** oriented perpendicular to the normal direction (i.e., a direction of a normal line) of the bottom plate **21**.

The converter casing **2** has connector **4** which firmly joints the bottom plate **21** of the first case body **201** and the top plate **22** of the second case body **202**. The connector **4** is located apart from the side plates **231** and **232**.

The capacitor **3** is, as can be seen from the perspective sectional view in FIG. **4**, of a rectangular parallelepiped shape. Specifically, the capacitor casing **32** is cuboid and has an open surface that is the greatest in area among side surfaces thereof. The potting resin **33** is exposed from the open surface of the capacitor casing **32** to make the potting surface **331**. The potting surface **331**, therefore, has an area that is the greatest among all the outer surfaces of the capacitor **3** (i.e., the capacitor casing **32**).

The capacitor **3**, as illustrated in FIGS. **1** and **3**, has four flanges **34** protruding from the capacitor casing **32**. Specifically, the flanges **34** extend from the side surfaces of the capacitor casing **32** which are perpendicular to the potting surface **331** in a direction parallel to the potting surface **331**. More specifically, each of the flanges **34** is located at substantially the middle of one of the side surfaces of the capacitor casing **32** in a height-wise direction of the capacitor casing **32** and protrudes laterally therefrom. Two of the flanges **34** are located closer to the potting surface **331**, while the other two are located closer to the side wall of the capacitor casing **32** which is opposed to the potting surface **331**.

The joining of the capacitor **3** to the bottom plate **21** of the first case body **201** is achieved by putting the four flanges **34** on tops of bosses (i.e., cylindrical supports) **211** extending from the bottom plate **21** of the first case body **201** and fastening bolts **11** into the bosses **211** through the flanges **34**.

The connector **4** is, as illustrated in FIGS. **1** and **2**, disposed between a plane extending over the potting surface **331** of the capacitor **3** and the side plates **231** and **232** which directly face the potting surface **331**. In this embodiment, the connector **4** is so located as to face the potting surface **331** of the capacitor **3**.

The capacitor **3** is oriented to have the potting surface **331** facing the center of the converter casing **2** in the normal direction of the potting surface **331**. Specifically, the capacitor **3** is arranged along longer sides of the storage chamber **203** (i.e., the side plates **231** and **232** of the converter casing **2**), as viewed from the normal direction of the bottom plate **21**. In other words, the capacitor **3** has a length extending substantially parallel to the length of the converter casing **2**. If the storage chamber **203** of the converter casing **2** is divided by a longitudinal center line **200** into two halves, the capacitor **3** is disposed in one of the two halves. The potting surface **331** faces the center of the storage chamber **203** (i.e., the center of the converter casing **2**) in a direction in which shorter sides of the storage chamber **203** extends (i.e., a direction perpendicular to the longitudinal center line **200**, that is, the normal direction of the potting surface **331**).

The connector **4** is, as described above, so located as to face the potting surface **331**. The connector **4** is, as illustrated in FIGS. **2** and **3**, made up of a first boss **41**, a second boss **42**, and a fastener (i.e., a bolt) **43**. The first boss **41** extends from the bottom plate **21** toward the top plate **22**. The second boss **42** extends from the top plate **22** toward the bottom plate **21**. The bolt **43** joints the first and second bosses **41** and **42** together. The first boss **41** has an internal thread **411**. The second boss **42** has a cylindrical recess or cavity **421** with an opening at the outer surface of the top plate **22**. The second boss **42** also has a hole **422** passing through the bottom thereof. The bolt **43** is inserted into the hole **422** through the cavity **421** and then fastened to engage the internal thread **411** of the first boss **41**, thereby joining the first and second bosses

41 and **42** together, which creates a firm joint between the bottom plate **21** and the top plate **22**.

As viewed in the normal direction of the bottom plate **21** in FIG. **1**, the connector **4** is located substantially at the center of the storage chamber **203** in either of the directions in which the longer sides of the storage chamber **203** extend and in which the shorter sides of the storage chamber **203** extend. In other words, the centers of major areas of the bottom plate **21** and the top plate **22** are joined together by the connector **4**.

The first case body **201** and the second case body **202** are joined together at mating faces thereof using a plurality of fasteners (not shown), such as bolts, disposed around outer peripheries of the mating faces, thereby completing the converter casing **2**.

The power converter **1** also has different types of parts other than the capacitor **3** installed within the storage chamber **203**. For instance, a noise filter **5** which works to remove electromagnetic noise from electric power inputted into or outputted from the power converter **1** is, as illustrated in FIGS. **1** and **3**, installed in the storage chamber **203**. The noise filter **5** is fixed on the bottom plate **21** of the first case body **201** through bolts **11**. FIG. **2** omits the noise filter **5** for the simplicity of illustration. The same is true for FIG. **6** and following figures.

Although not illustrated, the power converter **1** also includes a semiconductor module(s), a cooler and a control circuit board disposed in the storage chamber **203**. The semiconductor module works as a power converting device to execute a main operation of the power converter **1**. The cooler serves to cool the semiconductor module. The control circuit board has mounted thereon a driver or controller to control a switching operation of the semiconductor module.

The power converter **1**, as described above, may be mounted in automobiles, such as electric vehicles or hybrid vehicles, to drive the automobiles.

The beneficial effects, as provided by the above structure of the power converter **1**, will be described below.

The converter casing **2** is, as described above, equipped with the connector **4** which is used as a securing/joining member to establish a mechanical joint of the bottom plate **21** and the top plate **22** at a location away from the side plates **231** and **232**, thereby suppressing the physical vibration of the capacitor **3**.

A major factor in vibration of the capacitor **3** within the converter casing **2** is thought of as deformation-caused vibration of the bottom plate **21** of the first case body **201** to which the capacitor **3** is secured. Specifically, the exertion of vibration, as transmitted to the power converter **1**, on the capacitor **3** causes stress to be transferred from the joint of the capacitor **3** to the bottom plate **21**. Such stress will result in the deformation of the bottom plate **21**, which leads to the vibration of the capacitor **3** fixed on the bottom plate **21** in the converter casing **2**.

In order to alleviate the above problem, the power converter **1** is designed to have the connector **4** which mechanically joints the bottom plate **21** of the first case body **201** and the top plate **22** of the second case body **202** together and is located apart from the side plates **231** and **232** of the converter casing **2**. In other words, the connector **4** is provided on a portion of the bottom plate **21** which is usually lower in stiffness and is away from the side plates **231** and **232**. Such a location is effective in decreasing the deformation of the bottom plate **21**, thus resulting in a decrease in vibration of the capacitor **3** mounted on the bottom plate **21**. This also decreases the degree of stress acting on the terminals of the capacitor **3** which are connected to, for example, the noise filter **5** in the power converter **1**.

The capacitor **3** is designed to have the potting surface **331** which is the widest in area among the outer surfaces thereof, thereby resulting in a decrease in planar area of the bottom plate **21** occupied by the capacitor **3**. This enables the power converter **1** to be reduced in size. The connector **4** also serves to minimize the risk that the potting surface **331** of the capacitor **3** leans downward, thereby enhancing the suppression of vibration of the capacitor **3**.

The connector **4** is, as described already, disposed between a plane including the potting surface **331** of the capacitor **3** and one of the side walls of the capacitor casing **2** which directly faces the potting surface **331**. Such one of the side walls of the capacitor casing **32** is defined by one of the side plates **231** and a corresponding one of the side plates **232** which is joined to the one of the side plates **231**. The connector **4** is also located so as to directly face the potting surface **331** of the capacitor **3**. This results in an increased degree of rigidity of the bottom plate **21** against the stress which is exerted on the bottom plate **21** when the potting surface **331** of the capacitor **3** leans downwardly, thus enhancing the suppression of vibration of the capacitor **3**.

The second embodiment will be described below with reference to FIG. **5**.

The capacitor **3** is, like in the first embodiment, secured to the bottom plate **21** of the converter casing **2** through four fixing points or joints **340**. Each of the joints **340** is used as a capacitor fastener and made up of the flange **34**, the boss **211**, and the bolt **11**. The bottom plate **21** of the first case body **201** and the top plate **22** of the second case body **202** are mechanically joined together through two connectors **4**. If lines passing through the centers of the joints **340** in parallel to the normal line of the potting surface **331** of the capacitor **3** are, as illustrated in FIG. **5**, denoted by **300**, each of the connectors **4** lies on one of the lines **300**, as viewed from the normal direction of the bottom plate **21**. In other words, the center of each of the joints **340** and the center of a nearer one of the connectors **4** are aligned with a line extending perpendicular to the potting surface **331** of the capacitor **3**.

The capacitor **3** is, as described above, fixed to the bottom plate **21** of the converter casing **2** through the four joints **340**. Specifically, the capacitor **3**, like in the first embodiment, has four flanges **34**, two protruding from one of opposed side surfaces of the capacitor casing **32**. Each of the joints **340** of the capacitor **3** is created by a portion of one of the flanges **34** secured to the bottom plate **21** of the first case body **201** using the bolt **11**.

More specifically, the lines **300** are so defined as to extend in the normal direction of the potting surface **331** of the capacitor **3** through two of the joints **340** of the capacitor **3** which are closer to the potting surface **331** than the others are. Each of the connectors **4** is located on one of the lines **300**. In case of the geometrical structure of the capacitor **3** in FIG. **5**, each of the lines **300** additionally passes through one of two of the joints **340** which are farther away from the potting surface **331** than the other two. Two of the joints **340** which lie on the same side surface of the capacitor **3** and one of the connectors **4** are aligned with each other in the normal direction of the potting surface **331** in this embodiment, but however, either of the two of the joints **340** which lie on the same side surface of the capacitor **3** may be aligned with one of the connectors **4** along the line **300**. It is preferable that each of the connectors **4** is located on the line **300** extending through one of the joints **340** which is closer to the potting surface **331**. Each of the connectors **4** is arranged closer to one of the joints **340** which is closer to the potting surface **331**.

Other arrangements are identical with those in the first embodiment. The same reference numbers, as employed in the first embodiment, refer to the same parts, and explanation thereof in detail is omitted here.

The structure of the power converter **1** in the second embodiment serves to avoid the deformation of the bottom plate **21** which arises from the stress exerted from the joints **340** to the bottom plate **21**, thus minimizing the vibration of the capacitor **3**.

The third second embodiment will be described below with reference to FIG. **6**.

The power converter **1** of this embodiment is different from the one in the first embodiment in that the first boss **41** of the connector **4** is designed to be longer than the first embodiment in the vertical direction of the converter casing **2**.

Specifically, the first boss **41** extends from the bottom plate **21** of the first case body **201** to be longer than the side plates **231** (i.e., the height of the inner walls of the side plates **231**) so that the top thereof enters the top plate **22**. The connector **4** does not have the second boss **42**. The top plate **22** of the converter casing **2** has formed in the inside wall thereof a cylindrical recess **221** in which the top of the first boss **41** is fit. The top plate **22** also has a through hole **422** exposed inside the recess **221**.

When the second case body **202** is joined to the first case body **201**, the top of the first boss **41** will be inserted into the recess **221** and then placed in contact abutment with the top plate **22**. The firm joint of the top plate **22** to the bottom plate **21** is then achieved by inserting the bolt **43** into the through hole **422** and fastening it to establish engagement with the internal thread **411**.

Other arrangements are identical with those in the first embodiment. The same reference numbers, as employed in the first embodiment, refer to the same parts, and explanation thereof in detail is omitted here.

The structure of the power converter **1** in the third embodiment provides a simpler structure of the second case body **202** as compared with the first embodiment.

The fourth embodiment will be described below with reference to FIG. **7** which is a modification of the first embodiment.

The structures of the first boss **41** and the second boss **42** of the connector **4** are, as can be seen from FIG. **7**, opposite to those in the first embodiment. Specifically, the first boss **41** of the first case body **201** has a cylindrical recess or cavity **413** with an opening at the outer surface of the bottom plate **21**. The first boss **41** has a hole **412** passing through the bottom thereof. The second boss **42** of the second case body **202** has an internal thread **424**. The bolt **43** is fastened into the second boss **42** from the first boss **41** to establish a firm joint between the first boss **41** and the second boss **42**.

Other arrangements are identical with those in the first embodiment. The same reference numbers, as employed in the first embodiment, refer to the same parts, and explanation thereof in detail is omitted here.

The fifth embodiment will be described below with reference to FIG. **8** which is a modification of the first embodiment.

The second case body **202** does not have the side plates **232**, in other words, it is shaped as a flat plate. The first case body **201** is designed to have the side plates **231** higher than those in the first embodiment. In other words, each of the side plates **231** corresponds to a combination of the side plate **231** and the side plate **232** in the first embodiment. The first boss **41** of the first case body **201** extends from the bottom plate **21** to have the same height as that of the side plates **231**.

When the first case body **201** and the second case body **202** are fitted together, the tops of the side plates **231** will be placed in contact abutment with the major surface of the second case body **202**. Simultaneously, the top of the first boss **41** is also put in contact abutment with the major surface of the second case body **202**. The firm joint of the top plate **22** to the bottom plate **21** is then achieved by inserting the bolt **43** into the through hole **422** and fastening it to establish engagement with the internal thread **411** formed in the first boss **41**.

Other arrangements are identical with those in the first embodiment. The same reference numbers, as employed in the first embodiment, refer to the same parts, and explanation thereof in detail is omitted here.

The structure of the power converter **1** in the fifth embodiment provides a simple structure of the second case body **202** as compared with the first embodiment.

The structures of the first case body **201** and the second case body **202** may be shaped to be opposite to those in FIG. **8**. Specifically, the first case body **201** may be formed by a flat plate, while the second case body **202** may be designed to have the same configuration as that of the first case body **201** in FIG. **8**.

The sixth embodiment will be described below with reference to FIG. **9** which is a combination of the first embodiment and the second embodiment.

Specifically, the connector **4**, like in the first embodiment, includes the first boss **41** and the second boss **42**. The first boss **41** extends from the first case body **201**. The second boss **42** extends from the second case body **202**.

The second case body **202** is shaped as a flat plate and has substantially the same configuration as that in the fifth embodiment of FIG. **8** other than the second boss **42**. The first case body **201** is shaped to have substantially the same configuration as that in the fifth embodiment other than the length of the first boss **41**.

Other arrangements are identical with those in the first embodiment. The same reference numbers, as employed in the first and firth embodiments, refer to the same parts, and explanation thereof in detail is omitted here.

The seventh embodiment will be described below with reference to FIG. **10** which is different from the first embodiment in that the connector **4** is partially formed by the capacitor **3**.

Specifically, the power converter **1** is designed to have the capacitor **3** joined to the top plate **22** of the second case body **202** in addition to the bottom plate **21** of the first case body **201** to make the connector **4**.

More specifically, the capacitor **3** has a flange **35** formed on the top surface facing the top plate **22** of the second case body **202**. Similarly, the top plate **22** has a flange **222**. The joint of the capacitor **3** to the top plate **22** is achieved by connecting the flange **35** of the capacitor **3** and the flange **222** of the top plate **22** together through a bolt **43**, thereby joining the top plate **22** of the second case body **202** and the bottom plate **21** of the first case body **201** together to complete the converter casing **2**.

Other arrangements are identical with those in the first embodiment. The same reference numbers, as employed in the first embodiment, refer to the same parts, and explanation thereof in detail is omitted here.

The structure of the converter casing **2** is useful in suppressing the vibration of the capacitor **3** without sacrificing the volume of the storage chamber **203** in the converter casing **2**.

The eighth embodiment will be described below with reference to FIG. **11** which is different from the first embodiment in that one of fixing points or joints **540** of the noise filter **5** to the bottom plate **21** of the first case body **201** is also connected to one of the joints **340** of the capacitor **3** to the bottom plate **21**.

Specifically, the noise filter **5** is mounted on the bottom plate **21** in addition to the capacitor **3**. The noise filter **5** is coupled to the capacitor **3** through a bus bar **12**. The noise filter **5** is fixed to the bottom plate **21** through the joints **540**. The joints **540** are used as converter-component fasteners to fasten the noise filter **5** (i.e., a converter component) to the converter casing **2**. One of the joints **540** is mechanically fastened to one of the joints **340** which are, as described above, used as capacitor fasteners to secure the capacitor **3** to the bottom plate **21**.

The noise filter **5** is, as described above, joined to the capacitor **3** through the bus bar **12** and also secured to the bottom plate **21** by the bolts **11** at the joints **340**. One of the four joints **540** of the noise filter **5** which is closest to the bus bar **12** is mechanically secured to one of the four joints **340** of the capacitor **3** which is closest to the bus bar **12** using one of the bolts **11**.

Other arrangements are identical with those in the first embodiment. The same reference numbers, as employed in the first embodiment, refer to the same parts, and explanation thereof in detail is omitted here.

The ninth embodiment will be described below with reference to FIG. **12** which is a modification of the eighth embodiment in which one of the joints **540** of the noise filter **5** and one of the joints **340** of the capacitor **3** are firmly secured to a rectangular base **212**.

The base **212** has a given thickness protruding from its surrounding surface of the bottom plate **21** (i.e., the major surface of the bottom plate **21**) and is secured to or formed integrally with the bottom plate **21**. One the joints **540** and one of the joints **340** which are located adjacent each other are fastened to the common base **212**. Specifically, one of the flanges **54** of the noise filter **5** and one of the flanges **34** of the capacitor **3** are joined to the base **212** through the bolts **11**, respectively.

Other arrangements are identical with those in the first embodiment. The same reference numbers, as employed in the first embodiment, refer to the same parts, and explanation thereof in detail is omitted here.

The use of the base **212** secures good stability in connecting the joints **540** and the **340** together and to the bottom plate **21**.

The tenth embodiment will be described below with reference to FIGS. **13** and **14** which is a modification of the ninth embodiment of FIG. **12** in which the bus bar **12** is fastened to the bottom plate **21** along with either or both one of the joints **540** of the noise filter **5** and one of the joints **340** of the capacitor **3**.

In the example illustrated in FIG. **13**, one of the joints **340** of the capacitor **3** is secured using the bolt **11** to the base **212** on the bottom plate **21** together with the bus bar **12**. In an alternative example in FIG. **14**, one of the joints **540** of the noise filter **5** is secured using the bolt **11** to the base **212** on the bottom plate **21** together with the bus bar **12**.

Although not illustrated in the drawings, the bus bar **12** is fastened to the bottom plate **21** along with both one of the joints **540** and one of the joints **340**.

Other arrangements are identical with those in the ninth embodiment. The same reference numbers, as employed in the ninth embodiment, refer to the same parts, and explanation thereof in detail is omitted here.

The structure of the power converter **1** in the tenth embodiment works to suppress the vibration of the bus bar **12** acting on the capacitor **3** and the noise filter **5**.

While the present invention has been disclosed in terms of the preferred embodiments in order to facilitate a better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments and modification to the shown embodiments which can be embodied without departing from the principle of the invention as set forth in the appended claims.

In the eighth to tenth embodiment, the noise filter **5** is illustrated as being one of components of the power converter **1** which is electrically connected to the capacitor **3** through the bus bar **12**, but however, another component such as a reactor may alternatively be joined to the capacitor **3**.

The positional relation between the first case body **201** and the second case body **202** is not limited to the one illustrated in the drawings. The bottom plate **21** is not necessarily disposed beneath the top plate **22**. For example, the bottom plate **21** may be located above the top plate **22** or so arranged as to face the top plate **22** in the horizontal direction.

The potting surface **331** is, as described above, defined by one of the outer surfaces of the capacitor **3** which is the greatest in area, thereby resulting in a decrease in planar area of the bottom plate **21** occupied by the capacitor **3**, which allows the power converter **1** to be reduced in size thereof. For instance, in the case where the capacitor **3** is of a cuboid shape, the capacitor **3** will have three pairs of opposed surfaces. The potting surface **331** is, therefore, defined by either of the opposed surfaces which are the widest in area among the three pairs. The opposed surfaces of each of the three pairs may be slightly different in area from each other. However, in the case where the capacitor is substantially cuboid, the opposed surfaces may be viewed to be equal in area with each other, meaning that either of the opposed surfaces may be defined as being the widest in area.

The electrical connection between the capacitor **3** and the noise filter **5** may be achieved by a conductor other than the bus bar **12**.

What is claimed is:

1. A power converter comprising:

a converter casing which is made of an assembly of a first case body and a second case body and has a storage chamber defined therein, the first case body including a bottom plate, the second case body including a top plate which faces the bottom plate, at least one of the first case body and the second case body having side plates which extend from a corresponding one of the bottom plate and the top plate to the other;

a capacitor which is secured to the bottom plate within the storage chamber of the converter casing, the capacitor including a capacitor casing and a capacitor device which is disposed within the capacitor casing and sealed with potting resin so as to have a potting surface through which the potting resin is exposed outside the capacitor casing, the capacitor being fixed on the bottom plate with the potting surface oriented perpendicular to a normal direction of the bottom plate; and

a connector which mechanically connects the bottom plate of the first case body and the top plate of the second case body and is located away from the side plates.

2. A power converter as set forth in claim **1**, wherein the potting surface is defined by one of outer surfaces of the capacitor which is the greatest in area.

3. A power converter as set forth in claim **1**, wherein the connector is disposed between a plane including the potting surface of the capacitor and one of the side plates which directly faces the potting surface.

4. A power converter as set forth in claim **3**, wherein the connector is so located as to face the potting surface of the capacitor.

5. A power converter as set forth in claim **3**, wherein the potting surface of the capacitor faces the center of the converter casing in the normal direction of the potting surface.

6. A power converter as set forth in claim **1**, wherein the connector lies on a line which passes through a joint of the capacitor to the bottom plate in parallel to the normal direction of the potting surface, as viewed from a normal direction of the bottom plate.

7. A power converter as set forth in claim **1**, wherein the connector is partially formed by the capacitor.

8. A power converter as set forth in claim **1**, wherein a component of the power converter which is connected to the capacitor through a bus bar is secured to the bottom plate through joints, and wherein the capacitor is secured to the bottom plate through joints, at least one of the joints of the capacitor being fixed to at least one of the joints of the component of the power converter to the bottom plate.

9. A power converter as set forth in claim **8**, wherein the at least one of the joints of the capacitor and the least one of the joints of the component of the power converter are both fastened to the bottom plate.

10. A power converter as set forth in claim **8**, wherein the at least one of the joints of the capacitor and the least one of the joints of the component of the power converter are both fastened to a base which protrudes from a surface of the bottom plate.

11. A power converter as set forth in claim **8**, wherein the bus bar is fastened to the bottom plate along with either or both one of the joints of the capacitor and one of the joints of the component of the power converter.

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